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High spectral efficiency optical CDMA system based on guard-time and optical hard-limiting (OHL)

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Abstract: An optical CDMA system based on 2D optical orthogonal codes is described. System simulations show that a high spectral efficiency is achievable by adding a guard-time to the codes and an OHL at the receiver.

OCIS codes: (060.0060) Fiber optics and optical communications; (060.4080) Modulation; (060.4230) Multiplexing; (070.0070) Fourier optics and optical signal processing; (070.4550) Optical correlators; (070.6020) Signal processing

Optical CDMA (OCDMA) technology is of interest because of its potential to support bursty, asynchronous concurrent communication and thus maximize channel utilization. Much OCDMA research is based on optical orthogonal codes (OOCs) because they can be imlemented with intensity modulation and direct detection techniques (IM/DD). It is known that OOCs are degraded by multi-access interference (MAI) that increases with the number of concurrent users, usually limiting the number of concurrent users to a small fraction of the available code set. The literature usually proposes that MAI can be adequately suppressed by using complex receiver structures that include OHL, double hard-limiting (DHL), and DHL coupled with interference estimation [1,2,3,4]. Sometimes the additional constraint of synchronous operation is invoked [2], but this takes away from the random access benefit of OCDMA.

We have designed an OCDMA technology demonstrator (TD) based on a set of 32 2D OOCs [5]. The TD design has been captured in a system simulation (R_Soft LinkSIM) to explore and refine the system concept. Based on the simulation results, we have added a guard-time to the 2D codes generated by combinatorics. Similarly, we have incorporated an OHL in the correlator (decoder). A typical 2D code is shown in Figure 1; the shaded portion is derived from combinatorics and the unshaded portion is the guard-time. The construction and properties of the 32 2D OOCs used in this investigation are given in [5]. For purposes of implementation, the two dimensions of the code are wavelength and time (W/T codes). The guard-time increases the code dimension (rows*columns) by a factor of two, but the pay-off is a doubling of the number of error free users that can be supported.

Figure 2 shows the TD architecture and design that has been captured in LinkSIM and developed as hardware. The system requires RZ modulation (12.5% duty cycle), encoders and decoders based on array waveguide gratings (AWGs), and delay lines proportional to the OCDMA chip time (=100 ps in the case of GbE data rates per user). The 50% GT is implemented by impressing the 2D code in the first half of the bit time and zeroes in the other half. The OHL is effected by peak power power balancing or clipping the wavelength channels in the decoder.

Figure 3 shows the results of the simulation: 10^-9 and 10^-12 BER are achievable with 32 concurrent users, with guard-time and OHL alone. The spectral efficiencies of 32/64 (=0.5 bit/s/Hz) with guard-time and OHL, and 16/64 with guard-time only, are superior to those reported for other OCDMA 2D codes [6-8]. We believe this efficiency is a result of the wavelength and time-slot re-use inherent in our codes, unlike the rules for time-spreading/frequency-hopping and prime codes [6-8]. Experimental results based on the TD will be reported elsewhere.

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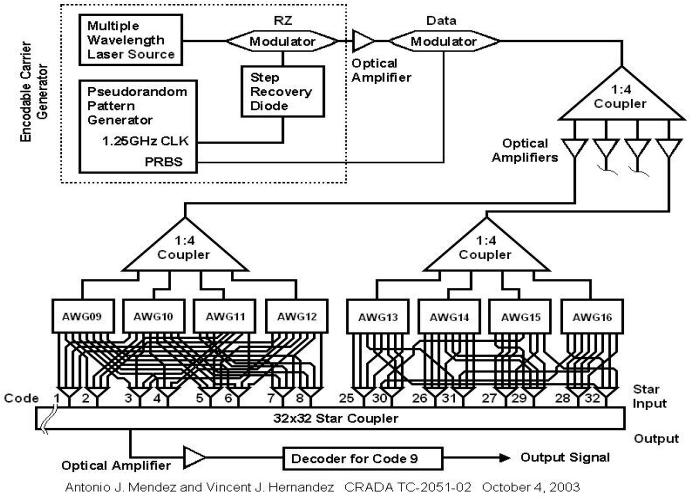
0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Fig. 1.Typical 2D Code wit h Guard-time; the rows are implemented as wavelengths and the columns as time-slots.

Fig. 2. Architecture of the OCDMA Technology Demonstrator→



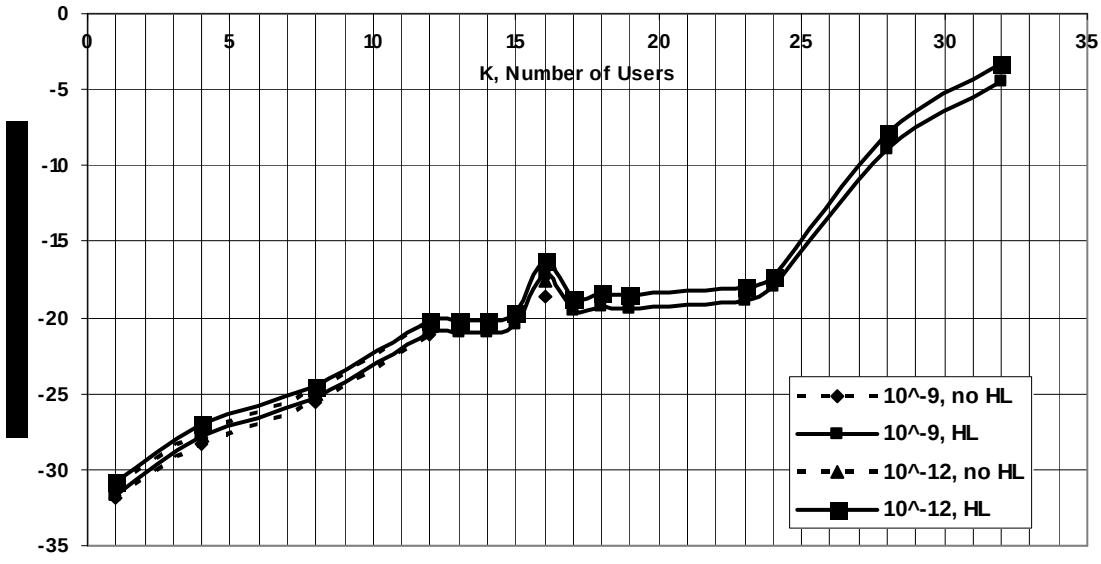


Fig. 3. Received power Required to Achieve the Indicated BERs, One to 32 Users.